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With

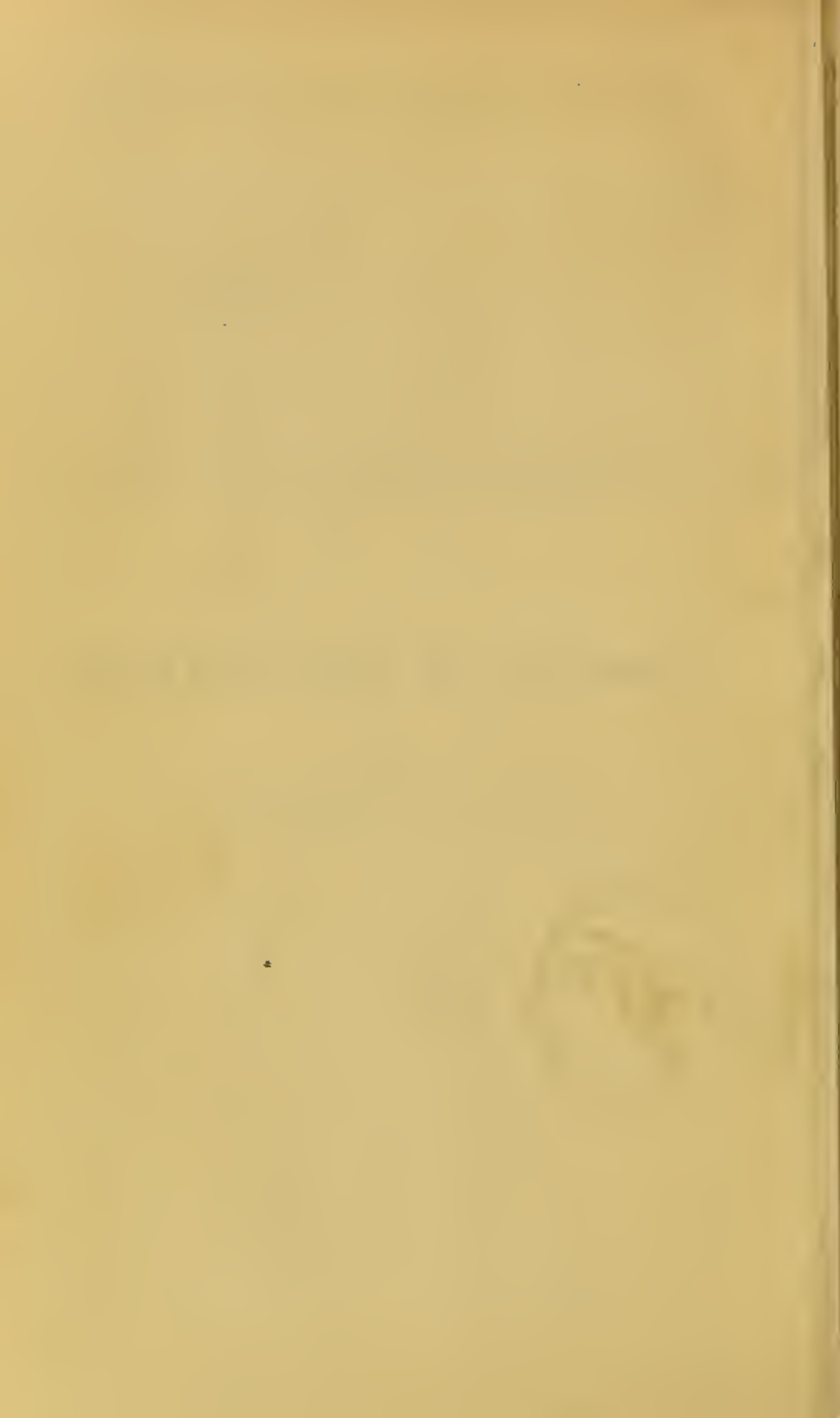
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PYROLOGY, OR FIRE ANALYSIS.

BY

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PYROLOGY, OR FIRE ANALYSIS.

1. Pyrology, as distinguished from ordinary blowpipe manipulation, may be described as the art of inducing chemical changes in substances from which their *composition** can be concluded, by the scientific application to them of fire, and the use of *acid* as well as alkaline fluxes for purposes of solution and of separation.

2. The term "Pyrocone" is used instead of that of "flame," employed by writers on the blowpipe, which last expression is here only applied to flames without a definite shape (*vide* paragraph 25), both because such a distinction is evidently a more correct phraseology, and because it prevents otherwise unavoidable confusion when both kinds of fire are produced in the same operation. For similar reasons the word "blowpipe," which seems a coarse and inexpressive appellation, equally applicable to a pea-shooter and the tubes of an organ, will be relinquished in these pages for the term "Pyrogène."

Pyrocones.

3. Pyrocones are divided into two classes, (*a*) natural and (*b*) artificial; (*a*) is the shape candle and other flames assume in air when left to themselves; (*b*) is that formed by treating (*a*) artificially as follows:—

4. On the application of a fine jet of air or breath, such as is impelled by operators with the pyrogène, to one side of the base of the natural pyrocone, the unburned gases in the centre are apparently expelled; the luminous cone, unless the blast is too weak, entirely vanishes, and what now appears is a long *solid* tongue of blue light, terminating in a point of needle-like fineness with a violet-coloured cone enveloping the apex, and extending, with a more obtuse termination beyond it, to a distance commensurate with the strength of the blast.

5. If we take the natural pyrocone afforded by ignited spirits or other light hydrocarbon producer, and blow into the centre of it with a mouth pyrogène, the jet of which is kept at some distance from one side of the cone, we observe two *synaxial* pyrocones formed by the blast, the bases of which are contracted or enlarged proportionately with its strength or weakness. If we approach the jet of the pyrogène so as to touch the side of the spirit-lamp pyrocone, and blow with greater violence, the inner or blast cone becomes invisible from the accelerated movement of the air; but we must analogically conclude that its basic diameter is contracted, and its length extended proportionately with those changes in the outer or *visible* pyrocone.

* In the term *composition* is included the quantitative as well as qualitative estimation.

6. That the air or breath from the pyrogene is driven *through* the longitudinal axis of the artificial spirit-pyrocone is also easily proved by the

Fig. 1.

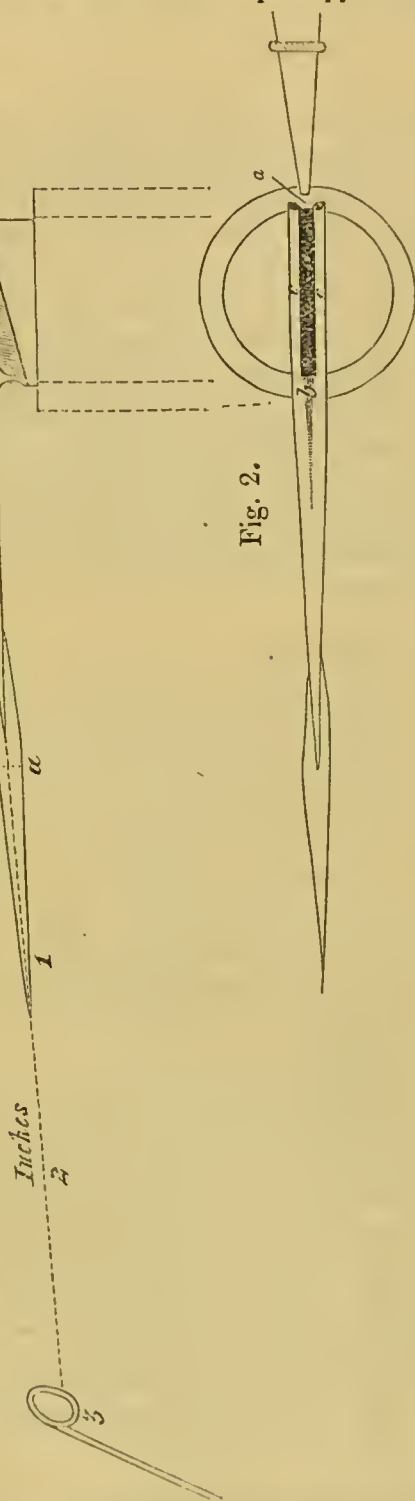


Fig. 2.

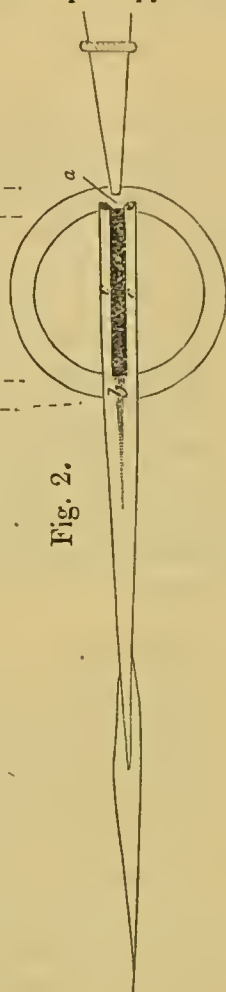


Fig. 4.

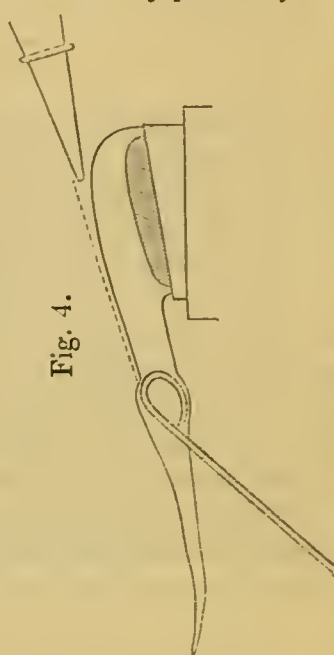
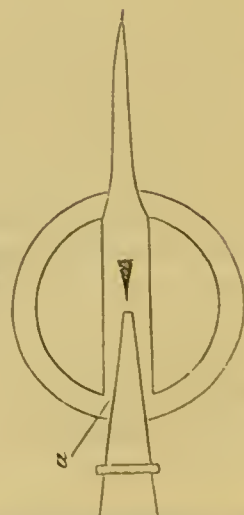


Fig. 3.



operator blowing with still greater violence, when the apex of the cone will

be observed to be broken up by the blast at the under extremity, the sides remaining intact, so that the form is now that of a hollow cylinder.

7. Very different is the pyrocone produced by the attempt to blow into the natural one afforded by the flame of ignited oil*, wax, coal-gas (not previously mixed with air as in the Bunsen burner), or other dense hydrocarbon. The blast cone no longer penetrates the blue flame, but moves *above* it, drawing out, as it were telescopically, a *solid* pyrocone from under its base, so that the two cones are no longer synaxial but conjunctive (fig. 1).

8. If we view this pyrocone from above, the diagram (fig. 2) is something like what we see. All ascending heat from the lamp is completely stopped; whereas we could not view the spirit-pyrocone from a like position without burning the face, because in the first case the natural pyrocone is bent, as it were, under the blast, but in the second merely bored through by it.

9. It will be seen from fig. 2 that the hollow nucleus of the natural pyrocone, which we have assumed to be filled with unburned gases, is traversed over its whole length by the blast cone from the jet, showing the wick of the lamp underneath as a black band, the breadth of which is directly proportional to the diameter of the base of the blast cone, and therefore inversely so to the strength of the blast, which, blowing in the short side *a* of the blue or hydrocarbonous perimeter *into* its long sides *c, c*, causes these latter to rise slightly like flame-walls on either side, and draws them along with it until they combine at *b* to form a solid pyrocone underneath it, as above described.

10. If the short side *a* be burst by the insertion of the jet, instead of by the blast, the shape of the latter, as seen from above over the wick, is that represented in fig. 3, the size and power of the resulting pyrocone being immensely diminished.

11. If, therefore, the blast in pyrological operations were driven *through* the long axis of the oil- or gas-lamp artificial pyrocone, as is generally assumed, and as is undoubtedly the case with the *spirit*-cone, we could not (1) see the lamp-wick as through a *transparent* medium like air, and (2) the heat ascending from the upper part of the pyrocone would be felt upon the face of the operator stooping over it; but it must be here observed that, to produce these effects, the volume and strength of the blast must bear a certain proportion to the size of the natural pyrocone.

12. It would be reasonable to expect from the above that the spirit- and oil-lamp pyrocones should possess different properties, and this is the fact. The pyrogenical or artificial cone of the former cannot, or can but feebly, attain the results produced by the latter. Filled with breath-vapour, instead of being solid, it has too much heating-power, while the enclosed gases interfere both with the oxidation and the reduction of the subject of analysis.

* Cocoa-nut oil (if it be perfectly pure) affords by far the best pyrocone, and coal-gas almost the worst, for the purposes detailed in paragraph 15.

13. It follows also, from a consideration of fig. 2, and the facts detailed in paragraph 9, that the central portion of the wick or fuel in ordinary pyrological lamps is unutilized; and in fact, if an oil-lamp be used, having two thin wicks instead of one thick one, and these be slightly pressed apart in the front (as at *a*, fig. 2), it will be found that a pyrocone of nearly double power will be produced by a similar blast and expenditure of fuel*.

14. Keeping the assumed fact of the superincumbency of a blast cone, and the consequent solidity of the blue pyrocone underneath in remembrance, we can readily understand that a roundish object placed in the latter about the centre of its longitudinal axis, which has a diameter equal to or less than that of the pyrocone, will be wholly enveloped by the ignited gas or gases of which the cone is composed, so as to form a kind of bulb or jacket round the front, *i. e.* that side towards the base of the pyrocone whence the current proceeds. The object is thus apparently preserved from communication, not only with atmospheric oxygen, but with unignited gas of any kind. Such an envelopment is termed

The Hydrocarbonous Pyrocone (Symbol H. P.) (fig. 4).

15. The behaviour of different substances when held steadily in the hydrocarbonous pyrocone causes it to be a synthetical and analytical agent of great value to the pyrologist. Substances of a viscid nature (not salts), as phosphoric or boric acid, become coated, after a few minutes' insertion, with a shining lustrous film having an extraordinary resemblance to a metal†, which, when gold or silver oxides are previously dissolved in the bead, becomes tinged with yellow in the first case, and with a silvery shade in the second, much as alloys of those metals would. This film evidently increases in thickness according to the length of time it is immersed in the hydrocarbonous pyrocone, for after a short immersion the glass is still semitransparent; but when held a longer time it becomes opaque.

16. The film thus formed is very hard, being unsusceptible to the point of a penknife. It has no taste, or, if any, that of a metal, while the taste of the oxidized phosphoric acid is sharp and acidulous. After the application of the tongue, an iridescent tarnish is left like that of sulphur upon silver; in fact none of these films will stand long exposure to a damp atmosphere. They are so very thin and hard that it seems impossible to remove any portion from the glass (which remains vitreous in the inside) with the forceps, or even by breaking up the whole bead.*

17. Sulphur in the viscid or red and resinous state is also changed by this treatment to a metallic appearance on its outer surface; but to produce this reaction, the pyrocone must be very perfect and of an unmodified blue colour, or the sulphur will be at once ignited and burn away. When

* Messrs. Price and Co. have manufactured, to the order of the writer, pyrological candles with a double wick on this principle.

† These films are difficult to produce with coal-gas, on account of its general impurity. *Vide* paragraph 4.

once prepared in this way, sulphur has no further tendency to burn, and it then has the remarkable property of giving, in a glass of phosphoric acid, reactions similar to those of copper, viz. green hot, and blue-green cold after treatment with a peroxidating pyrocone (to be hereafter described); but green hot and cold after a reducing pyrocone has been applied*. Ultramarine might owe its blue colour to this fact.

18. When a roundish mass of silica or alumina, or of both combined, is held in the hydrocarbonous pyrocone, it becomes quite black; and as this blackness is not merely on the surface, but throughout the mass, it would appear to be due to a decomposing effect exerted by the latter upon the pyrocone itself, and not a mere deposition of soot, which might have been supposed to have been mechanically carried along by the blast upon its surface. Alumina, however, appears to become partially fused, and thus forms into roundish or botryoidal swellings, while silica presents a steel black mass to the lens with shining metallic-looking points in it. These two omnipresent and almost universally combined earths, therefore, may be thus pretty correctly and extremely rapidly distinguished†.

Alkaline Earths in II. P.

19. Lime, strontia, and, to some extent, baryta and magnesia are not thus carbonized by treatment with the hydrocarbonous pyrocone, and may therefore when pure, be easily thus distinguished from the two first-mentioned earths. For lime, especially, a quantitative assay may be approximately made by slaking the mass thus treated in distilled water, when it will remain dark or grey or white, according as the lime exists in lesser or greater proportion. Above 80 per cent. of lime will cause the mass to remain perfectly white. The oxide of iron does not interfere with this reaction.

20. This property, which lime possesses, of remaining perfectly white and of resisting all tendency to reduction during such treatment, renders it an excellent medium for the detection of chlorides and fluorides, which seem to separate after a time from the lime, and to form some combination with the carbon of the pyrocone, the lime having no such tendency; for instance, in chloride of calcium, after a few minutes of this treatment, a small black patch, round in proportion to the sphericity of the mass, is formed on the side next the current of blue flame, which can be easily seen through the lens to be not soot, and seems to have a sweet taste; but if such a mass be often quenched in distilled water, and as often re-treated in the hydrocarbonous pyrocone, the black patch will shortly assume a metallic and white appearance.

21. Fluorides after the above treatment exhibit an irregularly shaped patch, also next the direction of the hydrocarbonous current; but this patch, instead of being black, has a changeable green colour like some of

* These effects are only in part producible by a gas-pyrocone. *Vide* paragraphs 4 & 7.

† The writer, by compressing the tip of the platinum jet so as to form a slit there, instead of a round orifice, produced a very perfect II. P.

the aniline compounds, and, after some quenching with water, a metallic appearance, but still green.

22. A very curious result is obtained by the treatment of bicarbonate of soda in the hydrocarbonous pyrocone. After a short time violent ebullition commences in the melted bead; bubbles of some (carbonic acid?) gas are seen to rise with great rapidity through it while red-hot. In this state of violent ebullition, fragments are projected from the mass, which, when examined through a lens, are found to be black hollow spheres like microscopic shells. Notwithstanding the loss occasioned by the ejection of these projectiles, the mass, if now carefully examined by a lens, will be found to consist partly of caustic soda, and partly of a black substance, solid and even angular and shining like a piece of coal. This substance is proved to be carbon by its deflagration when heated with nitre, and its formation is proved to be not due to a deposition of soot from the lamp-flame, by the fact that the similar treatment of chloride of sodium will produce no such result.

23. If any of the "earths" be held on platinum-wire after being made into a paste with a little distilled water in a hydrocarbonous pyrocone, those which carbonize in such a situation, as alumina and silica, being slightly heated in an oxidating pyrocone for a few seconds so as to just burn off the carbon, and if the mass be then saturated with cobalt solution, lime and strontia will immediately turn a distinct blue; and of these two, if allowed to remain exposed to the air for a time, the lime will slowly turn green, the strontia brown*. The previous addition or existence of iron sesquioxide will cause these to turn, instead of blue, green in the first instance. All the other earths, if pure and not in a chemically caustic state, become pink with cobalt solution; and if then they are approached carefully to the natural pyrocone of a spirit-lamp, this pink colour deepens to a rich carmine†. Of these earths, alumina and magnesia will (as is known), when treated with a peroxidizing pyrocone, change, the first to a deep blue, the second to a pale flesh or salmon-colour. Silica in this case turns a distinct purple, even in presence of oxide of iron; lime, baryta, and strontia a grey or grey-black. We thus obtain a nearly new chromatic series between the common "earths" of considerable value in analysis, as follows:—lime (*a*) and strontia (*b*) *blue*, changing on exposure to air (*a*) to green and (*b*) to brown. Alumina (*a'*), silica (*b'*), baryta (*c'*), and magnesia (*d'*) *pink*; changing on treatment with a peroxidizing pyrocone (*a'*) to blue, (*b'*) to purple, (*c'*) to grey-black, and (*d'*) remaining pink.

24. Berzelius, and after him Plattner and other writers on blowpipe analysis, tell us we "are not to take notice of any changes of colour in a substance to which cobalt solution has been applied *previous* to the further application to it of an oxidating flame; for the colour imparted, blue, red,

* Fluoride of calcium *remains* blue.

† Oxide of *zinc* thus treated affords a beautiful peach-colour; oxide of *tin*, after P. P., a green.

or black, proceeds from the cobalt solution only, and not from any of the ingredients;" from which statement it is evident that we have hitherto lost some of the most valuable qualitative indications of cobalt, due to the important fact that lime and strontia are rendered caustic by much less heat than the other "earths," and therefore dehydrate the cobalt solution after treatment with a hydrocarbonous pyrocone, rendering it blue, which none of the other earths will do. If the colours "proceed from the cobalt solution only," how is it that lime turns *blue* and baryta *red* when it is thus applied?

Fish-tail Flames.

25. If a pyrochromatic substance be held on the loop of a platinum-wire in a rapid hydrocarbonous current, produced by blowing strongly, the current is broken upon it so as to form a kind of fish-tail flame at its rear, *i. e.* the side turned *from* the base of the pyrocone, in the blue matter of which its front is enveloped as usual. The inner sides of this fish-tail flame will, after a short time, be observed to be deeply and continuously tinged with the colour which is the chief characteristic of the substance burned*. A far stronger pyrochromatic reaction is thus obtained than by holding the substance in the position usually adopted, of what is called "the point of the outer flame," or, in fact, in an oxyhydrogen pyrocone; for here the superposed blast is too violent, and carries away the colour as soon as formed.

The Oxyhydrogen Pyrocone. (O. P.)

26. In which the object is held as at *a*, fig. 1. It is commonly called "the oxidating, oxidizing, or outer flame;" but that the two first of these appellations are incorrect is shown by the fact that when some metallic oxides, as those of gold, silver, or mercury, dissolved in a flux more delicately sensible to oxidation and reduction than borax or microcosmic salt, *viz.* phosphoric acid, are held in this position, the bead, so far from being further oxidized, immediately precipitates its contents, and becomes dim or opaque in consequence.

27. This pyrocone appears to be caused by the intermingling of the two currents—of air and ignited hydrocarbonous matter, its broadest part being at *a*, where they may be supposed to cross each other, giving it a slightly oblate appearance.

The Peroxidizing Pyrocone. (P. P.)

28. In order to produce the full effect of this pyrocone, the object must be held at a distance of three inches from the point of the blue. It can be produced, but not long sustained, by the mouth, as a very strong blast is necessary to impart sufficient heat to an object at such a distance (3, fig. 1).

The Bunsen Blowpipe.

29. Before leaving the subject of pyrocones, it is necessary to mention

* The substance should occasionally be dipped in distilled water.

that the ingenious blowpipe of Bunsen, by which the breath is *forced* into a jet of ignited gas itself, is utterly useless for the purposes, and to produce the results detailed in these pages. The pyrocone thus formed is indeed the counterpart of that produced by blowing into the pyrocone of a spirit-lamp, except that its temperature is perhaps higher, with the deleterious results mentioned in paragraph 12.

The Fluxes.

30. These are invariably supported on platinum-wire in the admirable and perfect manner invented by ГАНН, and, as soon as a pyrocone is applied, assume the form of a spheroidal bead, which revolves or spins round upon its centre with a rapidity proportional to the fluidity of the matter of which it is composed. The "glasses" or "beads" thus formed, with the oxides dissolved in them, may be quantitatively determined, as to their weight and size, by means to be presently described.

31. Berzelius informs us that "Cronstedt used but three reagents—basic carbonate of soda, borate of soda, and the double salt of phosphate of soda and ammonia. These reagents are still in use; and among the great number of those which have been tried since that time, not one has been found to replace either of these. It is singular enough that in the very beginning of the art, the very best reagents should have been hit upon." (Berzelius on the Blowpipe, p. 32.)

32. One of the objects of this paper is to attempt to show that the two last fluxes mentioned in the above paragraph are not only *not* "the very best reagents," but that they have, by the complicated and obscure results obtained necessarily from their compound nature, seriously retarded the progress of pyrognostic examination. For instance, speaking of the third flux mentioned, the metaphosphate of soda, produced from what is commonly called microcosmic salt, Berzelius says (p. 39), "its efficiency as a reagent depends principally on its free phosphoric acid; and it is preferred to this because the phosphoric acid cannot be kept without deliquescing, while at the same time it is much dearer, and is also easily absorbed by the charcoal. The salt of phosphorus shows, therefore, the action of an acid upon the substance to be tested."

Phosphoric Acid (Symbol P).

33. Now, if glacial phosphoric acid be heated until it melts into a substance of viscid or gum-like appearance, and be thus poured hot into a wide-mouthed stoppered bottle (which should also be hot when receiving it), it can not only be kept without deliquescing, but, when solidified by cooling in the bottle, may be carried about in the pocket without fear, kept for years in the most rainy climate, and allowed to remain even for hours with the stopper of the bottle off. It has also the great advantage of being now-a-days far more easily procured pure enough for the purpose from most respectable chemists even in out-of-the-way stations, as in India, in conse-

quence of its use in therapeutics, than microcosmic salt can be. It is used by simply dipping the red-hot platinum-wire loop and the glass, of whatever description, formed upon it into the bottle, when a fresh supply of phosphoric acid adheres to the hot bead, without the supply in the bottle being at all adulterated.

34. That the metaphosphate of soda does *not*, when heated, exert upon substances added to it the reactions of an acid, unless the basic soda be displaced by another base for which the acid possesses a greater attraction, must be evident to an ordinary chemist; and there would appear to be few substances for which phosphoric acid has a greater attraction than it has for soda; in fact, the most valuable pyrognostic reactions *primâ facie* of the acid upon substances have been lost to operators precisely because the salt it forms with soda *fails* to give us those acid reactions, as follows:—The acid effervesces violently with all carbonates, and with some of the metallic oxides, the salt does nothing of the sort; and the necessity felt by many mineralogists and geologists of carrying about in their pockets a phial of the unpleasant and dangerous hydrochloric or nitric acid is thus at once obviated.

35. The *acid* used to dissolve cobalt oxide in any considerable proportion is blue hot, but assumes on cooling a magnificent red-violet colour*, to which the modern word “magenta” is partly applicable. When soda or potash is applied to this glass in sufficient proportion (about 17 per cent.) to form the metaphosphate of those bases, the glass remains blue, and a standard of alkali for purposes of calculation is thus evidently obtained. But as cobalt oxide produces with this flux many shades of colour according to the quantity in which it is added, from a pale and scarcely perceptible pink to the deep crimson-violet above mentioned, and as these degrees of red are exactly azurized† by a corresponding strength or quantity of the alkali added, it is plain that a kind of chromatic scale or table of colours might thus be made, of great use in the quantitative measurement of alkalis on the one hand, or of cobalt oxide on the other, instead of the unvarying “blue” which we find opposite oxide of cobalt in all blowpipe tables.

36. Instead, therefore, of superfluously multiplying illustrations of the difference between the reactions of the pure acid used as a flux and of the assumed “free acid” in microcosmic salt, it will be better to give here in slight detail some of the more important of the former with various oxides.

Gold.

37. Is dissolved and oxidized by this flux in an O. P. (as at *a*, fig. 1), when added in minute portions of the leaf—a fact which suggests that P under these conditions is more powerful as a solvent than any one of the mineral acids. As stated in paragraph 26, the position (*a*, fig. 1) will precipitate the dissolved gold oxide, rendering the bead of a dirty or muddy

* Discovered by the writer on 12th July, 1869.

† Lithia and its salts will not apparently azurize this cobaltine glass, but afford with it a very pretty purple violet colour.

appearance, which the application of a P. P. (as at 3, fig. 1) will soon remove, the bead then appearing not merely diaphanous, but highly refractive. If this brilliant auriferous glass be now treated with a good H. P., the white metallic-looking film referred to in paragraph 15 is formed, with a slight but distinct shade of yellow like pinchbeck, which is apparently due to the gold in solution; and this bead may thus be made alternately diaphanous and metallic-looking as often as is desired.

38. If the auriferous transparent bead be carefully kept for some time about half an inch from the point of the whole pyrocone, or two inches from the blue, as at 2, fig. 1, a beautiful shade of bluish rose-colour flushes over it just as it is becoming cold*; and the production of this tint, which cannot be confounded by the dullest observer with the red violet of cobalt, or the amethystine tinge of titanio acid or manganese, is an excellent test of the skill of the operator, as well as of the delicacy of the pyroconical reactions in this flux, for a hair's breadth too far towards (3, fig. 1) will cause the glass to be diaphanous and colourless on cooling; while a corresponding error in the other direction towards 1 will, as has been mentioned, produce a muddy appearance.

39. Gold-leaf is more rapidly dissolved, and the above reactions more easily produced in a glass of *phosphate of lime*, which appears to be, under pyrological conditions, a more powerful solvent of metallic oxides than any other known flux. It will be afterwards described; but it has the disadvantage in analysis, referred to in paragraph 32, of being a salt.

40. The ruby colour bestowed by gold upon glass and fluxes would thus appear, by the experiment above detailed, to be due to an *exact* amount of oxidation. The oxides of tin and antimony, added with it to colour glass under the name of "purple of Cassius" &c., seem not to have any thing to do with the production of the colour†.

Silver.

41. The most infinitesimal trace of the oxide, or of a salt of silver, added to a bead of P, gives a copious yellow precipitate like cream, accompanied at *first*, if the bead be held in a P. P., as at 2 or 3, fig. 1, by a very beautiful but very transient rose-colour. This is such a delicate reaction for silver, that it will be at once obtained from most galenas; and although thus a most important test *qualitatively*, is too fine to admit of being used as a quantitative standard for the estimation of rich ores.

42. There are two ways of effecting this. First, for an ore supposed to contain only a small percentage of silver. If the slightly argentiferous glass be retained in the position 3, fig. 1, the yellow precipitate soon disappears, and the glass becomes clear, highly refractive, and brilliant. On

* The addition of fresh P at this stage brings out this beautiful reaction still more decidedly.

† No metal, not even gold, has any tendency to alloy the platinum-wire in this flux when kept under a P. P. [Phosphosilicate of lime gives with gold oxide a bead as blue and brilliant as a sapphire.—September 14th, 1872.]

changing its position in the pyrocone to that of *a*, fig. 1, at present called the "oxidizing flame," the yellow precipitate immediately and copiously reappears; but there is no visible mark or signification by which the operator can thus judge of the quantity of silver oxide added. When, however, this amounts to 5 per cent. of the whole glass, and the latter, rendered diaphanous by the first position, is suddenly and momentarily brought into the second one indicated above, or, better, to just the tip of the blue, from whence, however, it must be instantaneously removed, a very remarkable and very beautiful appearance results. It is that of an almost perfect imitation of a pearl, produced apparently by the reduction of the oxide *near* the surface to the metallic state, while a vitreous glaze or gloss is still retained *upon* the surface.

43. This, then, may be called the first standard of silver for ores containing that oxide up to 5 per cent., though of course it may be used for richer ones; but the following method is more rapid for a rich ore, provided there are no chromatic oxides present to interfere with the clearness of the glass.

44. Second, for rich argentiferous ores. If we continue adding oxide of silver to a weighed P glass, and dissolving it carefully as at 3, fig. 1, we shall find the glass remain diaphanous until 20 per cent. of the oxide has been added, when the yellow creamy precipitate again begins to appear, causing, for rich ores, 20 to be the standard of silver. Of course, in calculating results from these "standards," the ratio deducible from them must be of the *inverse* kind; that is, for instance, if we find an argentiferous ore requires to be added to the extent of 40 per cent. in order to produce the yellow precipitate in a P. P. as at 3, fig. 1, or just double the quantity of the pure oxide of silver to effect the same result, we take the proportion of Ag as just half of purity, or 50 per cent.

Mercury and the Volatilizable Metals in P.

45. If these oxides are taken upon the hot glass, and the mass inserted into a good H. P. as in fig. 4, they are neither volatilized nor dissolved. The volatile oxides under such conditions form part of the metallic-looking crust or film, which is invariably formed over the surface, and can thus be added in large quantity with a very trifling loss. If the mass be now treated with a P. P. as at 3, fig. 1, these oxides are rapidly dissolved, all of them bestowing on the P glass a brilliant golden yellow, especially arsenic acid, by which a glass is thus produced quite equalling in appearance the finest topaz.

46. If this glass be now returned to an O. P., as at *a*, fig. 1, the oxide is immediately precipitated with a dim, and often an opaque grey or grey-black appearance; and although mercuric oxide (for instance) is usually presumed to be of so volatile a nature that its reactions are not given in blowpipe tables, this mercurial oxide is so difficult to volatilize that the strongest O. P. will not clear the P bead from it, but only burn both slowly away.

Sulphur.

47. If sulphur be added to a P bead as described in paragraph 45, and then treated with a P. P., the curious result of chromatic reactions exactly similar to those of copper, *i. e.* green hot and blue cold, is produced. The addition of plumbic oxide heightens this effect; and the resulting blue bead is quite indistinguishable from a cupreous one placed alongside.

Nitrogen.

48. If a P bead be constantly dipped in the strongest possible solution of ammonia or in concentrated nitric acid, and immersed as often in a H. P., as fig. 4, numerous black specks will be found on the surface like carbon, but much more difficultly burned away. After a time these appear to combine with the metallic-looking film which is formed by the H. P., and the substance is then by no means easily volatilized. The glass thus impregnated with nitrogen will be found to be clear hot, yellow and gelatinous on cooling, therein exactly differing from those of the alkalies, the volatilizable oxides, and some of the earths, which are yellow hot and clear cold.

Oxide of Copper in P.

49. If we add pure cupric oxide to a weighed P bead, and treat it with a P. P. (2, fig. 1), we find that it takes exactly 5 per cent. of the whole bead to produce distinctly the peculiar *blue* of copper. The glass must be carefully held in the position indicated, as O. P. would leave it *green* *: 5 per cent., then, may be taken to represent the standard of copper for quantitative measurements as described in paragraph 44; but in such cases as Cu pyrites, where there is a chromatic interference of other oxides, something more is necessary.

50. It requires one third more than the weight of a P glass in sulphur to give it the cupreous blue appearance referred to in paragraph 47; that is to say, a 50 mgrs. glass of P requires 75 mgrs. of flour sulphur added by degrees for that purpose. But it is found that by treatment in H. P. the flour sulphur, when it assumes the metallic appearance referred to in paragraph 17, is reduced to one fifth of its bulk; so that 75 mgrs. of flour sulphur only represent 15 mgrs. of the allotropic sulphur, and 15, therefore, is taken as the standard of sulphur. It has also been ascertained that 16 mgrs. per cent. of oxide of copper, when added to this sulphurous P bead, cause it to remain *green* even after a P. P., probably on account of the disposal by the sulphur of the superfluous oxygen; 16, therefore, is taken as the equivalent standard of copper to sulphur. If we now add oxide of lead to the *green* cupreo-sulphurous P bead thus produced, we shall find that, on the addition of 24 mgrs. per cent. the glass will again appear blue; 24, therefore, is taken as the equivalent standard of PbO to sulphur.

51. Copper pyrites dissolved in a P glass has a dirty green appearance, without any shade of blue in it, after a P. P.

* This is not the case with borax or microcosmic salt.

As an example, it took 57·1 mgrs. of PbO to azurize a green Cu pyrites P bead of 100 mgrs.

PbO S per cent.
Then $24 : 15 :: 57\cdot1 = 35\cdot6$ Sulphur.

Cu
 $24 : 16 :: 57\cdot1 = 38\cdot0$ Copper.

Therefore the oxide of iron = 26·4 Iron.

This is not very wide of the actual composition of Cu pyrites as decided by chemical analysis, which is sulphur 34·9, copper 34·6, iron 30·5. The specimen treated was a rich one from Freiberg in Saxony*.

52. With rich ores, as the red oxide, the method (paragraph 49) is so delicate, that an assay roasted *through* platinum foil gave 4 mgrs. more in the hundred than it did unroasted. The best and safest plan is to have an azure P glass coloured with 5 per cent of CuO as a pattern, and place the assay alongside of it on a sheet of white paper.

Titanium and Tin in P.

53. A diaphanous P glass having either of these oxides dissolved in it will, after being held a considerable time as at 3, fig. 1, show (apparently) crystals, yellow with Ti, and white with Sn, produced in it. This result cannot be effected with the mouth, but only with a table pyrogene†.

Alumina and Silica in P.

54. Berzelius proposes (page 86) to estimate silica pyrognostically in a mineral thus:—"Every substance of an earthy or mineral nature, which melts with *soda* with effervescence into a transparent glass which remains transparent on cooling, is either silica or a silicate in which the oxygen of the silica is at least double the quantity of that of the base." This ingenious discovery, which is strictly correct in cases where it is applicable, and in such cases, therefore, most useful, is unfortunately inapplicable to those silicates in which the estimation of the silica is of the most importance. The so-called "alkaline earths," especially *Lime*, will not permit silica, though combined in any proportion, to yield a bead with soda transparent on cooling, and they seem also to prevent or cancel effervescence in the same.

55. After many comparatively futile attempts to separate and estimate

* Another mode of procedure with sulphides is to carefully add the roasted ore (which, by a method of roasting to be hereafter described, *invariably* loses just 17 per cent.) atom by atom to the P bead in a P.P. (when the CuO blue reaction will *first* appear) until the FeS *begins* to interfere with it; then deduct from the large amount of copper thus indicated the sulphur and iron as determined by roasting and protoxide of lead.

† Such as are sold at Freiberg by "Herr Bergmechanikus Lingke," manufacturer to the Royal University of that place: *vide* Plattner's 'Probirkunst mit dem Löthrohre,' vierte Auflage (Leipzig, 1865), p. 32, note.

alumina and silica in various ways, one of which is referred to in paragraph 18, which occupied the writer some years, the following plan, which ought from its simplicity to have suggested itself at first, has been followed with apparent success.

Nearly every oxide or substance is more soluble pyrologically in P than alumina and silica, while alumina is far more soluble than silica is. The "alkaline earths" are rapidly dissolved; and lime especially is not only dissolved, but forms a salt, referred to in paragraph 39, which will dissolve almost any thing but silica*.

56. It has been ascertained that alumina will dissolve to the extent of 20 per cent., and silica to that of only 6 per cent. in a P bead; and this result is not materially modified by lime. After those amounts respectively have been added, the undissolved alumina appears as white roundish fragments, like pieces of fat, the silica as a semitransparent mass like melting snow, so that they are thus distinguished without difficulty even in presence of lime or the alkaline earths.

Six per cent. is therefore taken as the standard of silica in quantitative calculations; but as 20, that of alumina, is inconveniently large, it is better to employ as the flux a P bead half saturated with 10 per cent. of pure alumina, and to make 10 the standard of that "earth."

57. A P glass saturated with silicic acid still dissolves a little alumina, but the converse is not the case; it is best, therefore, to test *qualitatively* for either earth with a P glass saturated with *alumina*.

Boric Acid (Symbol B).

58. Plattner and succeeding writers on the "blowpipe" made use of this substance for the purpose of separating metallic lead from copper in an alloy of the two by oxidizing the former, and therefore as a means of *affinage* of the latter metal†. In this operation, B appears to absorb litharge precisely as bone-ash does in eupellation; but it acts at the same time as a kind of shield to protect the copper from oxidation.

59. Berzelius employed B as a test of phosphoric acid in phosphates by the insertion through the mass of a piece of pure iron wire, which is corroded and fused if the phosphoric acid exists over 5 per cent.; but this reaction, to be effectual, presupposes the perfect solution of the substance containing the phosphate in B, which, as will be seen, can be effected with very few oxides indeed.

60. In fact it is precisely the insolubility of almost all substances but the alkalis in boric acid which gives it the extraordinary value it undoubtedly possesses as an agent of *separation*; and the following few examples will not only clearly demonstrate this fact to the impartial chemist, but show

* Borax dissolves silica pyrologically more completely than any known flux. The writer found that phosphoric and nitric acids, combined in about equal proportion, attacked and broke up the Berlin saucers in which they were boiled.

† Vide Plattner's "Probirkunst" &c., edition of 1865.

him that the fact itself has been utterly passed over by writers on the subject hitherto, and that the real analytical value of B, therefore, has remained unknown.

Oxides of Cerium, Didymium, and Lanthanum.

61. If a good specimen of the mineral "cerite" be powdered and applied to a bead of B in an O. P., the following phenomenon results. The substance appears to separate into three distinct parts:—(1) red-brown and resinous-looking round spots appear near, but not *on* the surface; (2) other round spots, more bulky or puffed out, nearer the middle of the bead, of a pale buff colour; (3) a slight milky turbidity through the bead, as though a finely divided precipitate were suspended throughout the whole mass. If what is sold or made by the chemists as "pure oxide of cerium" (generally a nut-brown powder) be applied to a B bead in like manner, precisely the same triplicate separation occurs, only the turbidity is very much less.

62. These round spots are observed to be round through a lens when viewed in *every* direction; they are therefore sphericles or globules*.

After considerably long treatment with O. P. the smaller buff-coloured globules will be dissipated throughout the bead, causing more turbidity with a slight shade of buff in it; but the red resinous globules remain unchanged, appearing white-hot in the red-hot bead (from which it appears that their fusing-point is higher than that of B), and may be collected, from their superior specific gravity, at the bottom of the bead, by careful manipulation with the point of the blue pyrocone, into one large globule.

63. Professor Stokes has found that, by treating this B bead with distilled water, the general mass is dissolved while the contained globules remain intact, the most minute of which may be thus perfectly extracted. They may be also extracted more quickly, but with less precision, by wrapping the bead when *quite* cold in paper, and tapping it gently upon an anvil with a light hammer, when the matrix breaks away from the globules. Added to a bead of P under O. P., the red globule first fuses to an intensely lemon-coloured mass on the surface, and then dissolves in the glass with effervescence, giving the reactions of ceric oxide. These red ceric globules have been discovered by Professor Stokes to contain also oxide of *didymium*, the absorption-bands of which, when spectroscopically examined, they show very distinctly.

64. It is therefore assumed that the red balls are composed of ceric + didymic oxides, and the buff-coloured ones of lanthanic oxide; while the turbidity is proved beyond reasonable doubt to be caused by lime, which with baryta are the only substances, except phosphoric acid, capable of causing this opaline turbidity on *first* application to the B bead†. At any

* This was written before the writer knew how to extract these globules: *vide* next paragraph.

† A trace of phosphoric acid applied to a bead of boric acid and heated in O. P. affords a glass when cool having an almost perfect resemblance to an opal.

rate, the so-called "pure oxide of cerium" is thus shown, by one simple operation, to consist in reality of no less than *four* substances.

Lime, Strontia, Baryta, Alumina, Silica, and Magnesia.

65. Of the alkaline earths, lime, as above mentioned, causes immediate turbidity over the whole bead, and when added in greater proportion, produces round spots suspended in the turbid mass. These spots are perfectly clear and colourless like drops of limpid oil in milk. When added in very large proportion, the clear spots collect in one large one, which, if still further addition of lime is made, absorbs the remainder of the turbid part, leaving the whole bead beautifully clear and colourless. The turbid part, therefore, would appear to be an attempted solution of the lime by the boric acid; the clear part, a complete solution of the boric acid in the borate of lime.

66. Strontia forms large beautiful vitreous-looking globules, quite transparent and even refractive; they have great specific gravity, and can be easily aggregated at the bottom of the bead. Baryta affords spheriules like fish-eyes, transparent at first, but soon becoming opaque. Magnesia is not at first acted on by B, but after a short O. P. resolves itself into opaque, white, and compact spheriules like miniature snow-balls; these, after long O. P., and consequent exhaustion of B, are clarified and become transparent, but are again rendered opaque by the addition of fresh B. It is concluded from this fact that these contained balls have a fixed relative proportion as regards quantity to the containing B. Alumina and silica remain as amorphous fragments, and do not congeal into globules; those of the former are white and opaque like pieces of fat; of the latter semi-transparent.

The Alkalies.

67. Soda, potash, and lithia appear to be the only substances which dissolve completely in boric acid in any proportion, and hence the value of the latter as a detective agent for them, and also as an alkalimeter; for if a very small trace of soda or potash contained in a mineral or salt be applied to a B bead having globules of cobalt (for instance) suspended in it, those nearest the side where the alkali is applied are dispersed and spread over that side as a pink suffusion. If 5 per cent. be added, the spheriules of cobalt disappear, the whole bead is clarified, and assumes a blue colour while hot, but remains pink on cooling. If 17 per cent. be added, the bead remains *blue* on cooling, and (in the case of soda) borax has been formed; but this method would probably be considered incomplete if it did not afford a means of distinguishing between, as well as of measuring these two alkalies; and this it does as follows:—

Vesiculation.

68. If the B bead, on the addition to it of the substance to be examined, shows, by the reaction above described, that an alkali is contained in the

latter, a fresh bead should be impregnated with a weighed portion of the substance, which should be dissolved as far as possible by an O. P. Then, the bead being rapidly removed from the point of the pyrocone, it should be blown into while red-hot with the jet of the pyrocone, which for that purpose should be advanced so as just to touch the ring of the platinum wire. If the bead be not too cold, the result will be that the whole mass is blown out into a thin clear bubble or vesicle about seventy times its first size, thus presenting a very large surface of the dissolved substance to be operated on. This vesicle should then be held in the operator's open mouth and breathed upon for some time, when, if the alkali has contained even a trace of potash (1 per cent. of KO affords the reaction), the vesicle will immediately become clouded over with a light blue film of the colour of a solution of quinine when held against the light. If only soda be present, the vesicle will remain clear but will begin to deliquesce. Lithia affords a tarnish like that of breath on a pane of glass, and the vesicle does *not* deliquesce.

69. This test for potash in presence of soda is so delicate that if two beads, even of borax, one containing a trace of potash, be vesiculated and allowed to remain in a moderately dry room for some time, the one containing the potash will in the course of a few hours cloud over, while the other will remain quite clear.

Determination of Gases by Vesiculation.

70. The B vesicle by itself will cloud over after a few minutes, but the appearance then is more white than blue; and if the clouded vesicle be approached to the flame of a spirit-lamp, this white coating is not removed until the flame almost touches it and shrivels the substance of the vesicle, whereas in the case of the addition of a trace of potash, the cloud flies as if by magic when the vesicle is even a considerable distance off.

71. The addition of *chlorine* to the B bead, made by dipping the bead in strong hydrochloric acid and treating as in paragraph 48, apparently causes the vesicle made therefrom to be still more sensitive to the action of gases upon its surface. It clouds over in common air almost the instant it is made. If held over a solution of *ammonia*, this nubilesceuce is prevented, and the vesicle remains clear. If held in a noxious or putrescent gas, creamy or brownish-white streaks are formed over the surface, which is otherwise clear. But the most characteristic reaction is that afforded by sulphuretted hydrogen, in an atmosphere of which this vesicle becomes rapidly pitted with circular spots as though it had suddenly taken smallpox. These spots through a lens are observed to be round radiated crystals, with a yellowish tinge near the circumference. After a short time, they rot into holes.

72. Another curious result of vesiculation is the crystallization of the surface in a moderately damp atmosphere in the course of ten or twelve hours. Borax-vesicles show these best; but the complicated nature of the salts formed renders conclusions from their crystallization very uncertain.

Microscopically viewed, however, these crystals are very beautiful, especially in polarized light; and it seems at any rate certain that silica and the silicates thus treated invariably crystallize in most elegant and beautiful arborescent appearances, the form taken by other salts being usually that of a disk, often of a leaf.

Cobalt, Copper, and Metallic Oxides.

73. The behaviour of these in B has not yet been fully examined; but such as have, promise results quite as interesting and important as those which may be derived from that of the earths. For instance, when an ore containing the oxides of cobalt and nickel, previously manipulated as in paragraph 90, is boracically treated as described in paragraph 61, the cobalt immediately congests into globules, which after O. P. appear blue-black, after H. P. red-purple through a lens; the nickel oxide, on the contrary, remains in amorphous fragments, which are bright green after O. P., and have a metallic lustre after H. P. Cupric oxide forms in O. P. balls of an indigo-blue colour, not easily distinguishable at first from those of cobalt; but in H. P. the cupreous globules immediately give out streaks of the red suboxide, which cannot be mistaken, though, of course, were further proof necessary, the addition of 5 per cent. of soda would form a pink glass from the first, and a blue one from the second. Iron oxide remains in amorphous fragments of a black-brown colour with a rusty halo or tinge round them, and is thus easily distinguished. Oxide of Uranium forms a stringy black mass with a yellowish opacity round, which the addition of soda dissolves to a bright pea-green bead. Molybdic acid affords many curious and beautiful changes, for a description of which there is not space.

Silver, Lead, and the Volatilizable Oxides.

74. None of these form either balls or fragments in boric acid, but spread over the whole bead as a milky precipitate, that of silver having a slight pinkish tinge. Nothing, therefore, can be easier than their separation thus from those metallic oxides which form balls or fragments, as the former of these can not only be collected or aggregated into one sphericle, but extracted from the cold bead with the greatest ease, as described in paragraph 63. It is obvious that this process would probably form an important method of extracting *silver* from its ores with very little loss; for the boric acid protects oxides contained in it from the direct effect of an O. P., which dissipates pure silver unprotected to the extent of 10 per cent. in a very short time.

75. Altogether, as a detective reagent, boric acid seems scarcely inferior even to phosphoric acid, while as a separating one it is quite unsurpassed.

Many hypotheses of the formation of these sphericles or balls have suggested themselves to the writer, but none with a sufficient weight of evidence in their favour to be stated here. They may be due (*a*) to capillary phenomena, (*b*) to the retention of a certain amount of carbonic acid (for of

the "carths" it is evidently only those forming carbonates which produce them), or (c) to some law or principle as yet not fully known.

76. A bead of pure boric acid is evidently more fluid in H. P. than in O. P., and the hydrated appearance of cobaltine balls in the former (paragraph 73) would seem to suggest the setting free of some constitutional water (?)

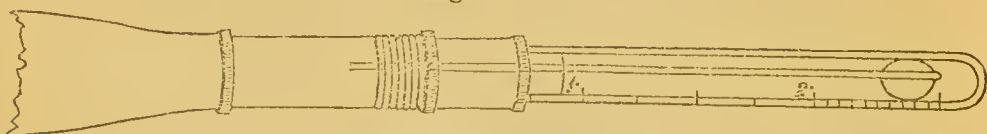
Phosphate of Lime.

77. This is a useful flux for purposes of mere solution, as referred to in paragraph 39. A curious phenomenon results from the application to the hot glass, containing a metallic oxide in solution, of carbonate of soda, which, instead of fusing in the glass under O. P., does so by itself at first, apparently drawing or precipitating the metallic oxide to itself. If a hot glass of phosphoric acid be applied to warm calcined lime, the mixture takes fire and burns with a very pretty pale yellow light, phosphate of lime being formed. This flux has been little investigated for pyrological purposes, having been thus first used by the writer.

Quantitative Analysis by "Glasses" or "Beads."

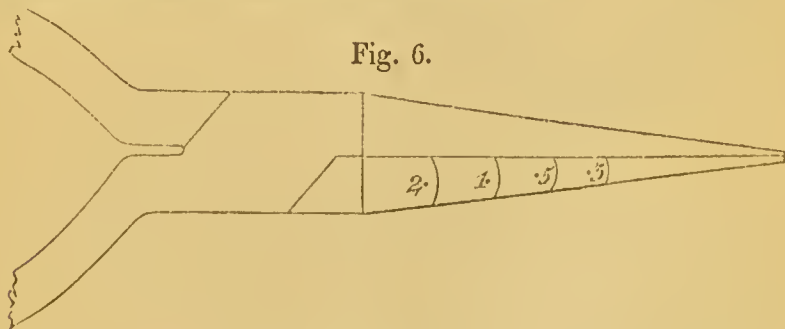
78. For this purpose it is evident that the glass must not only be weighed but measured; for, as both phosphoric and boric acids lose weight and substance in direct proportion after a strong O. P., some means of measuring the diameter of the bead, and of thus keeping it up to the mark, is required. Sufficient accuracy for this purpose seems to be afforded by a simple instru-

Fig. 5.



ment as that shown in fig. 5, representing a common glass tube which exactly covers a 50-mgr. bead of phosphoric acid. The graduations on the outside of the tube are for the purpose of showing the length of the platinum wire (in tenths of an inch), which of course is proportional to its weight, the thickness or diameter being the same.

Fig. 6.



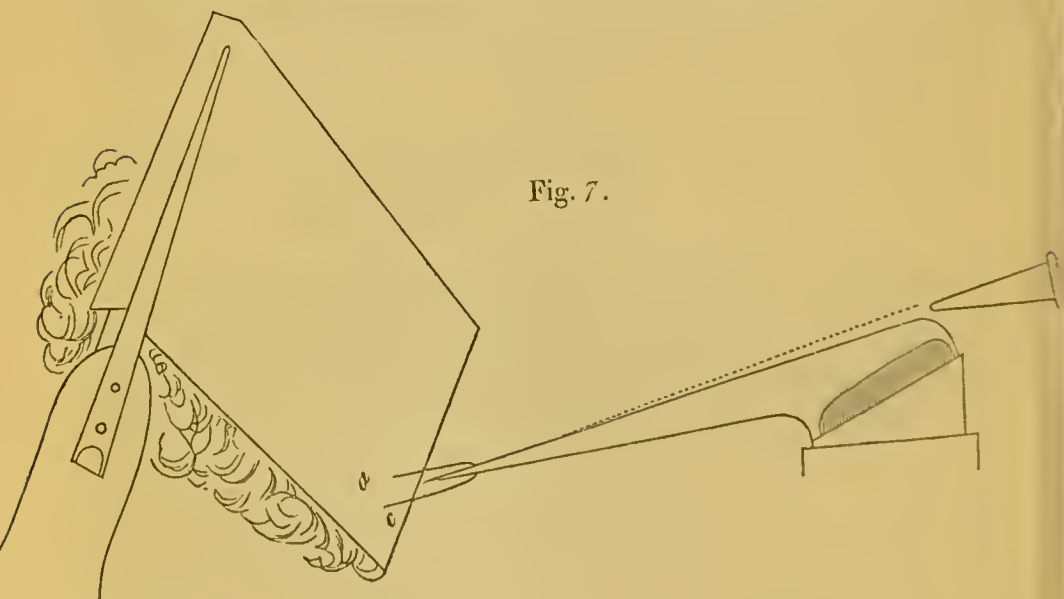
79. Fig. 6 represents the instrument with which the platinum wire is

twisted into a loop, which must be perfectly circular, and of a diameter corresponding to the size of glass required. It is a pair of common cage-maker's pliers with round but tapering legs; only the right (or left) leg should be graduated and figured, say, in tenths of an inch, to show the diameter of the loop made on the other one. Neither of these instruments, however, is to be understood as at all dispensing with the use of the assay balance, of which a beautifully portable description is now made cheaply at Freiberg; it indeed is indispensable, and to be referred to when any doubt is entertained.

Roasting through Platinum foil.

80. The cautions and directions against using the platinum which is supplied as part of all pyrological apparatus, to be found in most chemical works, are manifold and almost amusing. It would be better, if these directions are to be followed, to have no platinum foil at all than to have it and not use it; but in practice it will be found that there are comparatively few substances which injure platinum foil when heated *through* it, to such an extent that it cannot be advantageously used for months. The ore called "stibnite" is one of these, but with care even galena may be thus innocuously roasted.

81. The foil, which should be thicker than the usual English kind, can



be conveniently made into a small tray about 1.5×1 inch, and held, as in fig. 7, with a pair of brass pliers having steel legs, the subject of examination being deposited as a paste (made on a slab with distilled water) on its lower lip. The point of the pyrocone must then be applied to the *back* of the tray opposite the substance, and on no account is it to be directed upon its surface.

82. It will be found that only a certain and normal, not an uncertain and irregular degree of heat *can* thus be applied to substances which under pyrological conditions combine with oxygen or are reduced to the metallic state; and therefore that oxidation on the one hand is as exactly regulated as though it had been controlled by a balance, and that reduction on the other hand need not be feared, except in the case of the very fusible metals, as antimony or lead. For instance, copper pyrites roasted in this way will be found to lose exactly 17 per cent. and no more, however long or strongly the pyrocone has been applied. The same amount of sulphur is thus driven off from "copper glance;" and there can therefore be little reasonable doubt that 17 per cent. is the extent to which sulphur may be dissipated from copper ores without fusing both together.

Sublimation.

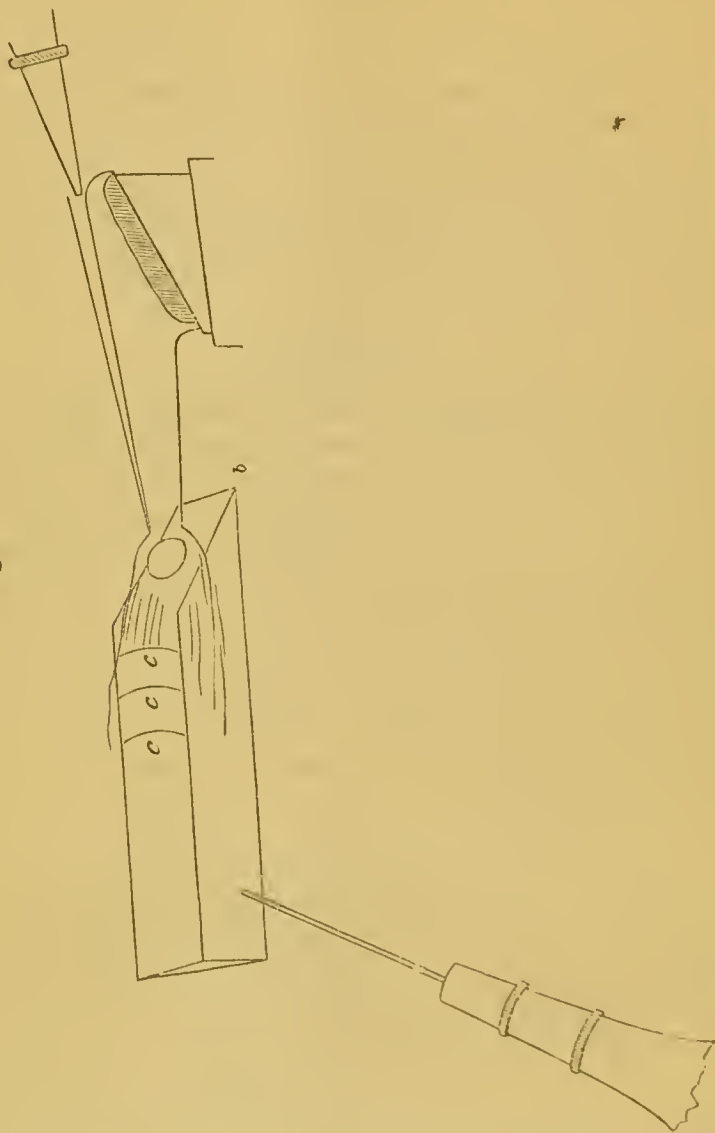
83. This is better performed on such a platinum tray held by steel-legged forceps than in the ordinary manner on charcoal or in a glass tube. By mixing a little common rust or lime with arsenic or antimony, the most timid operator need not fear injury to his platinum, which, however, it is far better to spoil than to lose a single valuable reaction. The addition of iron sesquioxide has another advantage; for it will be observed that the antimonial oxide mixed with it is deposited on the upper steel leg of the forceps unchanged as a *white* sublimate, but the arsenic oxide as an *orange* one, in consequence, it is presumed, of the ability of the latter to carry up a portion of the red iron oxide with it. This would appear to afford a valuable distinction between these two metals in toxicological cases, which even Marsh's test does not give.

84. If flour sulphur be treated in this way, and the upper leg of the forceps be sufficiently high to be out of its blue flame, for of course it ignites, the steel leg will not be found to have changed further than by being covered with a yellow varnish, which is apparently distilled sulphur; but if the leg be plunged warm into water, it will appear white from the number of bubbles caused by some chemical action upon it. If instead of sulphur only, a mixture of sulphur and any inorganic substance containing nitrogen, as gunpowder (only of course, for this purpose, that must be well watered and ground into a paste), be used, we shall find the forceps apparently unchanged; but after being plunged warm into water, the upper leg will come out perfectly *black*. No bubbles will be observed through the lens, but the leg, on drying, will be found covered with rust.

85. This curious reaction is also produced when sulphur is thus sublimated in company with such minerals as emit an empyreumatic or nauseous odour when heated in a matrass alone, as, *e. g.*, stinkstone. Such minerals, dissolved in a P glass, give also the nitrogenical reaction referred to in paragraph 48; and one of such (a black mineral found at Mussoorie in India, as hard as topaz, though consisting apparently only of silica, and

emitting a smell of burnt fat when heated in a matrass) produced, when dissolved to a supersaturated extent in borax, a fine cerulean-blue bead of extreme hardness*. Both this mineral and gunpowder (the latter alone, the

Fig. 8.



former combined with sulphur) were found, when ground with water in agate mortars, to give them a deep violet tint, best seen by transmitted light, which is quite ineradicable even by the strongest acids†.

86. If sulphur and clear drinking water be heated as at *a c*, fig. 7, a white sublimate is deposited on the polished leg of the forceps, similar in appearance to that afforded by fusing chloride of sodium. It was thus extracted, though in extremely minute quantity, from even distilled water. To observe

* Can the blue colour of the *sapphire* be due to this fact?

† Nitrate of silver gives the agate a purplish-black tint.

slight sublimates, the steel legs of the foreeps should be polished bright before use, and then pointed downwards near a window, when the slightest deposit will affect the appearance of the shining surface through a lens.

87. The distinction made by writers on the "blowpipe" between sublimates of metals by means of the different distances at which they are deposited from the assay on charcoal, is apparently based on an error, as these seem to be due chiefly to the violence or weakness, as the case may be, of the superposed blast (paragraph 7). This may be proved by causing the sublimate of the *same* metal, as antimony, to be deposited at different distances, as shown in fig. 8 at *c c c*, through modified blowing.

88. The same figure shows the manner in which it is proposed to utilize the whole effects of the hydrocarbonous pyrocone for substances which cannot be conveniently supported on platinum wire, as metals or alloys, by which the defects of large pieces of charcoal in breaking up and spreading out the pyrocone, and in absorbing and wasting so large an amount of heat, may be avoided. This is by sawing charcoal paste (made of C powder, flour, and water according to the directions given in Plattner's work) into parallelograms about $1\frac{1}{2}$ inch long by a $\frac{1}{4}$ inch deep, and bevelling or slanting off one end as at *b*. This is called a "charcoal mortar," and is supported by a common sewing-needle stuck into one side, as at *a*, figs. 8 and 10. A cavity is scooped at first in the slanting face of the mortar with the point of a penknife, or, better, an implement like fig. 9, which is the representation of a broken drift. After some use the mortar burns away as shown in fig. 10; but no fresh cavity

Fig. 9.

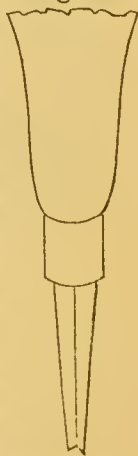
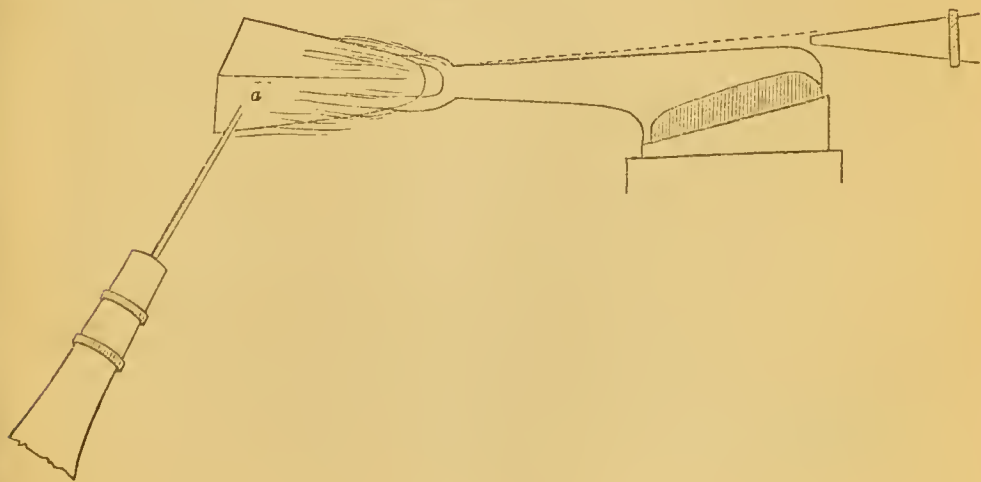


Fig. 10.



requires to be scooped, as the assay being hotter than the surrounding paste, burns a place for itself, while the great advantage is obtained by

the operator of being able to instantaneously cool and examine the assay at any time, by dipping the whole in a cup of water.

Aluminium foil as a support.

89. It has been found that pieces or strips of aluminium foil not *under* three inches long, withstand the strongest heat of the pyrogene without fusing as well as platinum does, over which the former metal possesses this great advantage, viz. that many metals, as gold, silver, lead, &c., or their alloys, may be fused *upon* it without the least fear of combination.

It is thus possible to use this beautiful metal as a support upon which to fuse most other metals, alloys, or metalliferous ores wrapped in a piece of soda paper, instead of upon charcoal—the advantages being cleanliness, portability, and even economy, for one strip will last out any number of pieces of charcoal. It is rapidly attacked, however, by chlorides and phosphates.

90. [Minerals heated in P. P. upon Al. foil afford extremely valuable indications of some oxides, which on charcoal would be fused and reduced; as, e. g., *Kupfer nickel* and *Speisscobalt*, which *thus* immediately yield a fine green oxide—"emerald nickel." (6th August, 1872.)]

ERRATUM.

Paragraph 15, line 7, for "dissolved in the bead," read "dissolved in the former bead."